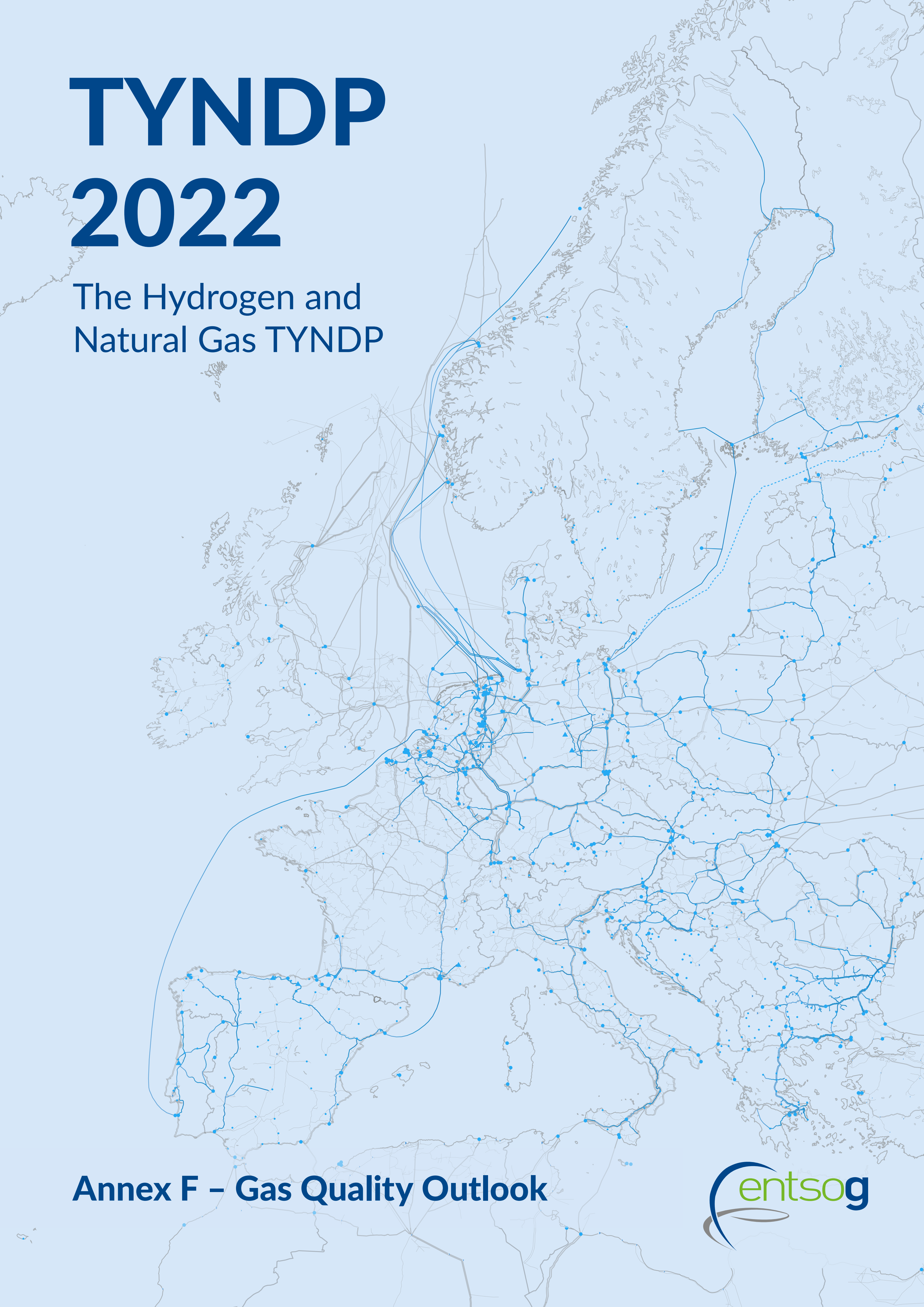


TYNDP 2022

The Hydrogen and Natural Gas TYNDP

Annex F – Gas Quality Outlook

entsog

TABLE OF CONTENTS

1 INTRODUCTION

Article 18 of the network code on interoperability and data exchange rules (Commission Regulation (EU) 2015/703) requires ENTSOG to publish, alongside the TYNDP, a long-term gas quality monitoring outlook (Gas Quality Outlook – GQO) for transmission systems in order to identify the potential trends of gas quality parameters and respective potential variability within the next 10 years.

The GQO shall cover at least the gross calorific value (GCV) and the Wobbe Index (WI), produce forecasts for different regions and be consistent and aligned with the TYNDP considering existing and new supply sources, based on reference gas quality values from previous years when available. For each region, forecasts are illustrated by charts that provide ranges within which the parameters are likely to evolve.

The TYNDP 2022 is the fourth edition incorporating the GQO. One of the main improvements in this edition is the inclusion of synthetic methane in the production scenarios. Identical to the TYNDP 2020 exercise, the influence of hydrogen on GCV and WI[1] is also included in this gas quality outlook. This report only provides initial assessments of the possible quantities of renewable, decarbonised and low-carbon gases. In this respect, the report does not prejudice the technical feasibility of injecting the projected quantities of such gases into the gas systems as this subject is still under investigation – and does therefore not constitute any legal responsibility on ENTSOG in this matter.

2 METHODOLOGY

The GQO is produced with a probabilistic approach based on a statistical characterisation of historical WI and GCV data supplied by TSOs for each different supply source. In the Input data subsection, a graphical representation of the used values for all the sources included in the study can be found.

The GQO is assessed with a Network Modelling tool considering predefined supply corridors/regions with different demand and supply scenarios. The result is a probability distribution of gas quality values for each assessed region and year.

For the GQO 2022, the TYNDP 2022 National Trends scenario is used as reference for 2030 and 2040, while the Best Estimate scenario is used for 2025. The National Trends scenario relies on bottom-up data for the indigenous production for natural gas and biomethane.

1 Although not addressed in this report, in TYNDP 2022 ENTSOs have identified the need for hydrogen supply considering two major technologies: P2G and Steam Methane Reforming/Autothermal Reforming (ATR) combined with CCU/S.

Additionally, in TYNDP 2022 scenarios, hydrogen and synthetic methane production through Power-to-Gas (P2G) is included as part of the modelling of electricity market and is, therefore, dependent on the price signals. In addition, ENTSOG requested members to provide data in line with the final National Energy and Climate Plans (NECPs). For the sensitivity of hydrogen blends, the same scenario (National Trends) has been used, and, similar to the conventional simulations, the outlook goes up to 2040

The underlying mathematical model is built on the following assumptions:

- The supply corridors and regions are defined like the regional groupings that develop the GRIPs:
  - South corridor: FR, ES, PT
  - South-North corridor: DE, BE, FR, IT, CH, LU
  - North-West corridor: SE, DK, DE, NL, BE, LU, FR, UK, IE
  - Baltic Energy Market Interconnection Plan (BEMIP) corridor: DK, SE, FI, PL, EE, LT, LV
  - Central Eastern Europe (CEE) corridor: DE, PL, CZ, SK, AT, HU, HR, RO, BG
  - Southern Corridor: IT, AT, SI, SK, HU, HR, RO, BG, GR
- The actual use of supply considered in 2025, 2030 and 2040 simulations is a result of the model taking into account the minimum and maximum supply potentials. More detailed explanation can be found in the Annex D to the TYNDP 2022[2].
- WI and GCV have only been collected at entry points to the EU transmission network and indigenous production points.
- For each supply source, the probability distributions of GCV and WI are derived from the historical data and they are assumed to be representative for the future developments of that source.
- Gas quality parameters per identified supply source are assumed to follow a normal probability distribution.
- L-gas has not been considered for different reasons:
  - L-gas is expected to have a declining contribution in the coming years.
  - The underlying network model does not make a distinction between L-gas and H-gas production.
- Biomethane and synthetic methane gas quality is assumed to lie within a common range for all production plants, irrespectively of the country where they are located.
- LNG is grouped as a single gas quality range, under the assumption that the same range of qualities can reach any terminal in Europe. The range used for the simulation is based on measured values from re-gasified LNG in different LNG terminals in the EU.
- Indigenous production data of natural gas have been aggregated per country, contrary to biomethane and synthetic methane.
- Hydrogen flows in blends simulations are considered as high purity (100 %) hydrogen.
- For those countries not listed in the input data section, a generic probability distribution has been assumed for their national production (NP). The NP range is built considering the highest and the lowest values across all indigenous production data.
- The existing infrastructure development level is considered in the analysis[3].
- Supply and gas quality figures are combined by means of Monte Carlo simulation.

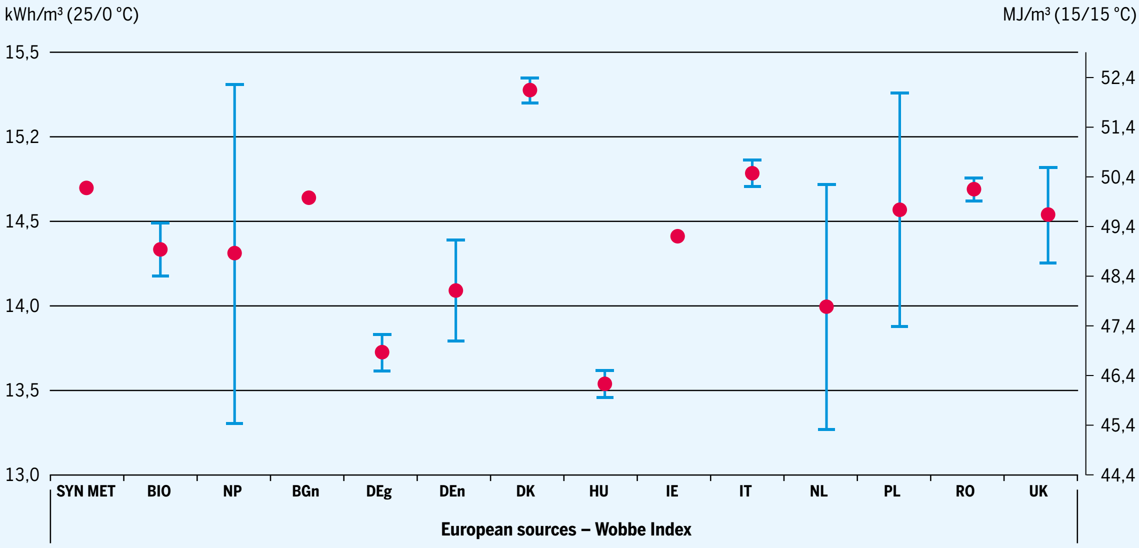
2 See TYNDP Annex D

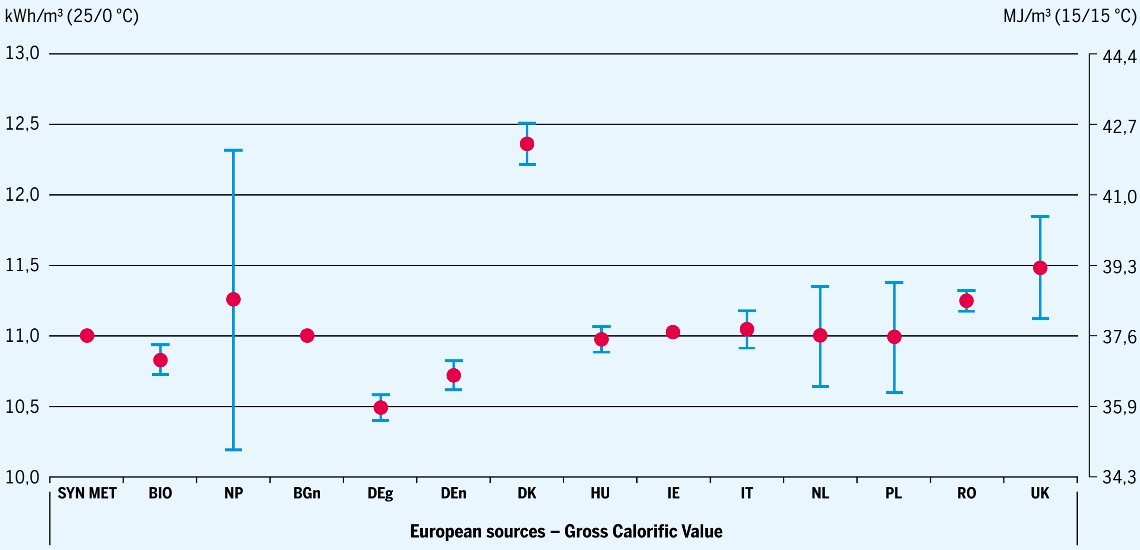
3 More information on infrastructure development levels are available in the TYNDP 2022 Infrastructure report

2.1 INPUT DATA

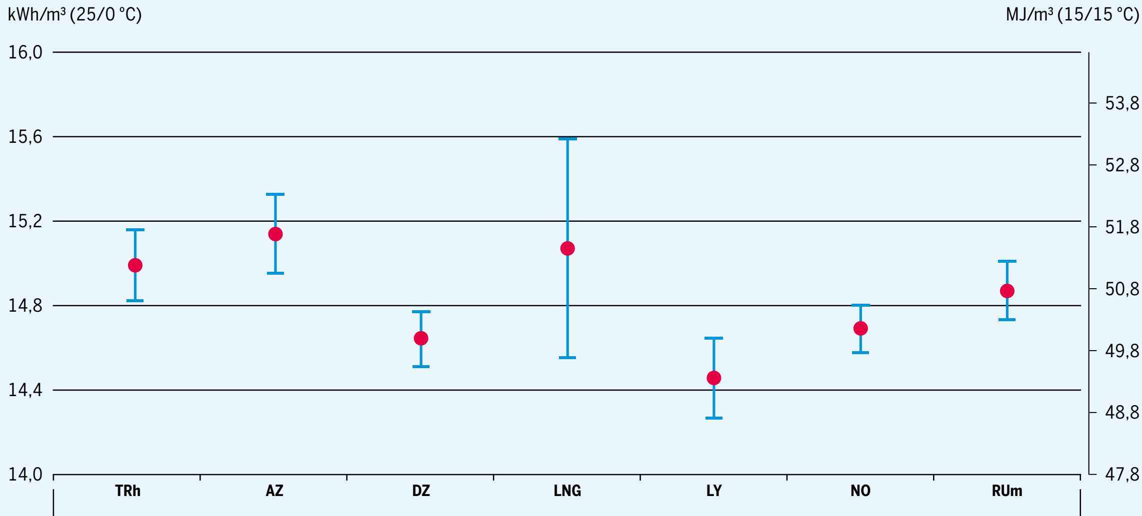
The average WI and GCV values used as input for the simulations are represented in the figures below. The error bars, also shown in the graphs, represent a range within which 95 % of the values fall. The WI and GCV values are expressed in kWh/m³ (25/0 °C) on the left axis while in MJ/m³ (15/15) on the right axis.

The figures below illustrate the WI and GCV of the European sources: national production of natural gas, biomethane and synthetic methane. Except for the countries indicated in the graphs below, a default value of WI and GCV is considered for national production, indicated as NP in the graph.

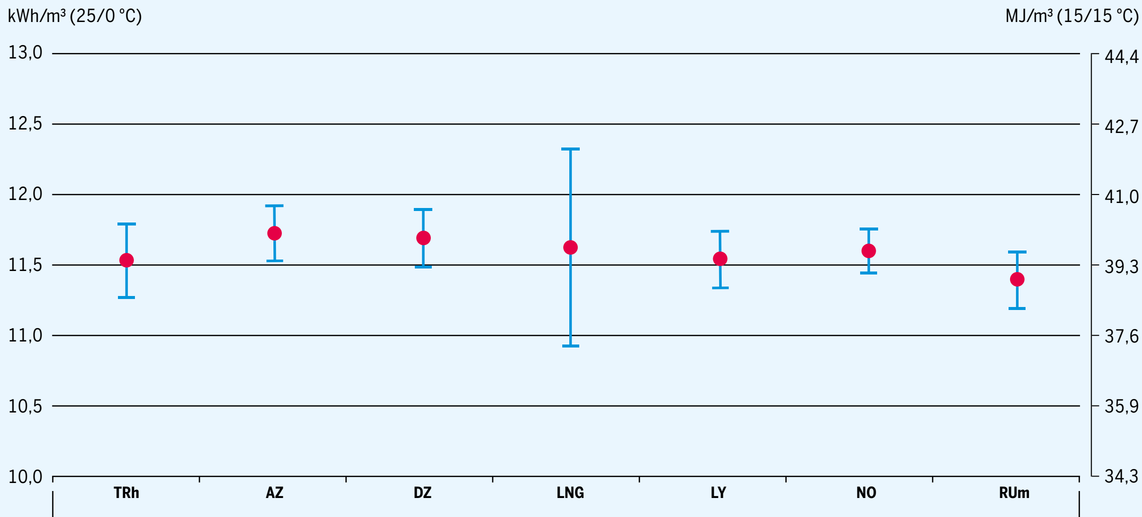




The figures below represent WI and GCV for the import sources considered in the current Gas Quality Outlook.



Import sources – Wobbe Index



Import sources – Gross Calorific Value

2.2 HYDROGEN INFLUENCE

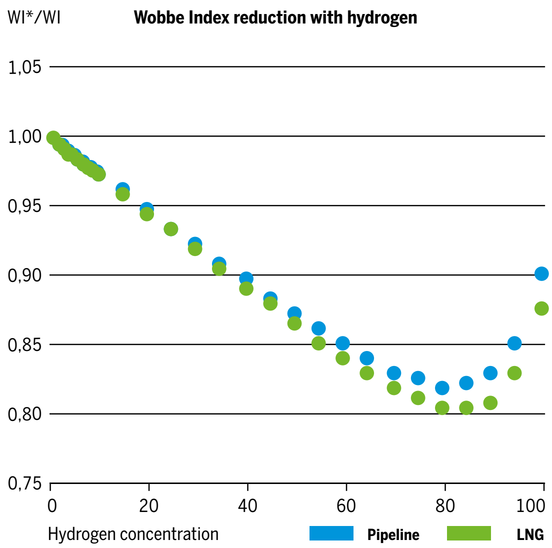
In this report, the influence of hydrogen injected into gas grids is considered, and the impact on WI and GCV in the upcoming years is analysed.

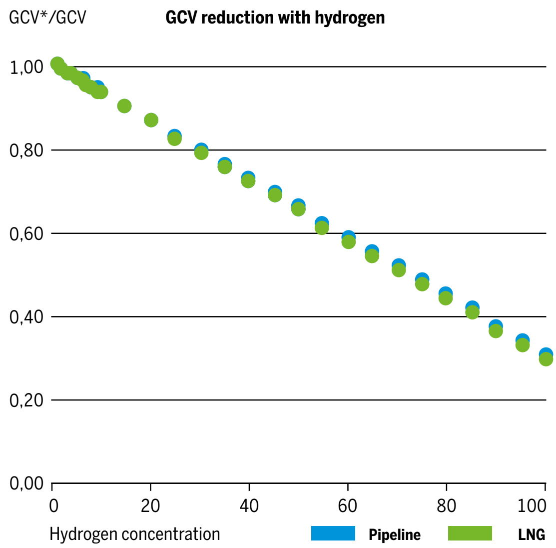
The impact of H_2 blending on Wobbe Index and Gross Calorific Value is well known and has been documented by different studies[4].

When H_2 is blended to natural gas, WI and GCV of the blend decrease compared to the case of natural gas only. The graphs below show the ratio between the combustion parameters, WI on the left and GCV on the right, with and without H_2. For both WI and GCV, the influence of hydrogen is approximately linear for concentrations up to 30 % hydrogen in volume. This assumption is made for all the calculations in this outlook where a hydrogen concentration up to 5 % in volume is considered.

The hydrogen showcase is provided in section 3.9. For this edition, the effect of two different hydrogen volume fractions on WI and GCV ranges has been analysed. The H_2 concentrations considered in this study are 2 % and 5 % in order to reflect the ongoing discussion for the revision of the EU Gas Directive and Regulation.

The results shown are built on the National Trends scenario for 2030 and 2040, and are based on the assumption that each supply source contains 50 % gas blended with hydrogen and 50 % not blended. Besides, the hydrogen showcase is built on average yearly data, thereby not illustrating the possible fluctuation in hydrogen injection in operation time scale.





4 See MARCOGAZ document: Impact of hydrogen in natural gas on end-use applications. UTIL-GQ-17-29.pdf

Picture courtesy of GAZ-SYSTEM

3 RESULTS

For each region analysed in the study, Russian supplies are used as the last resort gas source[5]. In order to identify trends in WI and GCV, the figures illustrated in the current section present a plot of the median (50 percentile) of the resulting probability distribution. The variability of gas quality parameters is depicted in two different ways:

- 2.5 and 97.5 percentiles are plotted in dotted lines to inform of the extreme values most likely to be found.
- Except for sections 3.1 and 3.2, the trends are presented on top of a surface plot illustrating the probability distribution of different gas qualities across years. The darker the background, the higher the probability. This plot serves to highlight the fact that the probability distribution of the output does not follow a normal distribution even if all input sources are assumed to do it. In general, for one given region and scenario different local gas quality bandwidths may be found between the two extreme percentiles. The width and intensity (probability) of each band comes as a result of the gas quality parameters of supply sources on one hand and their contribution to satisfy the forecasted gas demand on the other.

5 See Annex D to TYNDP 2022 further information regarding the supply price methodology

3.1 WOBBE INDEX OVERVIEW

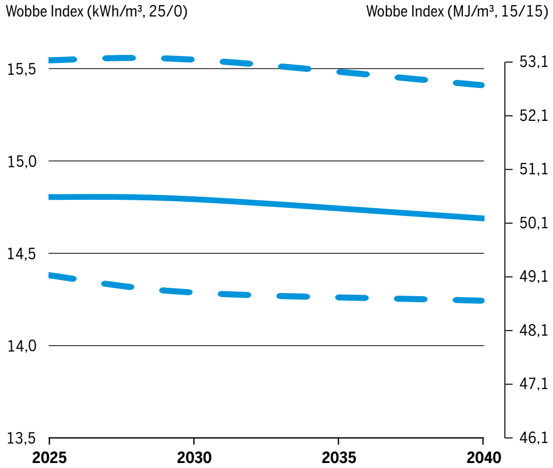
The evolution of median WI appears quite stable throughout the considered time frame, particularly in the North-West and South-North regions.

However, other regions like BEMIP and South show a decrease in median values from 2025 to 2040 because of a high share of, respectively, Norwegian gas and biomethane. In South Corridor and North-South, the median values show a slight increase from 2025 to 2030, followed by a decrease in 2040. This fluctuation can be linked to the substantial change in supply sources in 2030 as depicted in the TYNDP 2022 System Assessment Report[6].

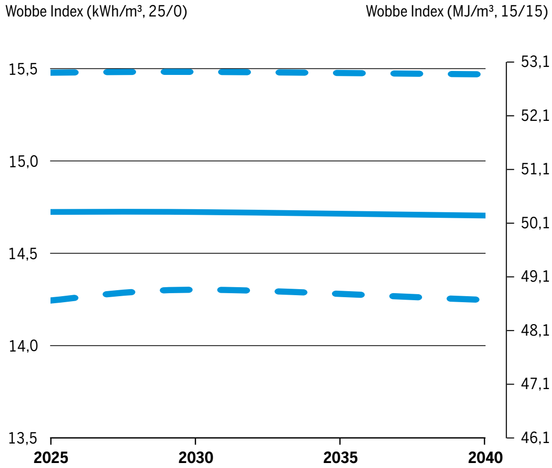
Regarding the extreme values, South-North, BEMIP and South-Corridor exhibit relatively stable trends in contrast to North-South, North-West and South.

For North-South and North-West regions, the variation in WI range is mainly due to the substantial decline in indigenous production by 2030. While for the South region, the GCV range shifts towards lower values in 2040 due to the significant share of biomethane.

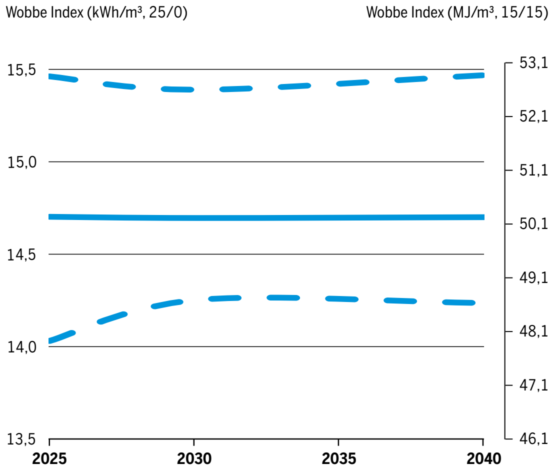
SOUTH WI



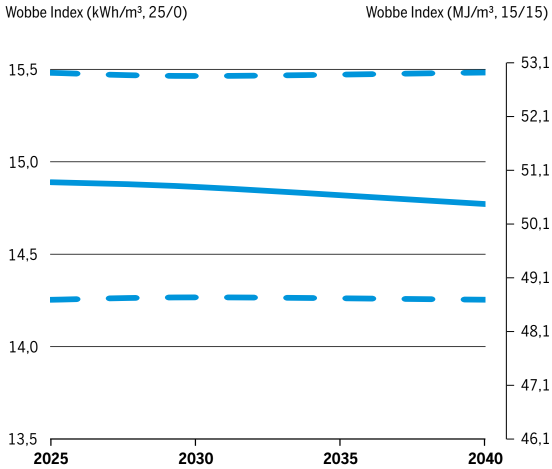
SOUTH-NORTH WI



NORTH-WEST WI

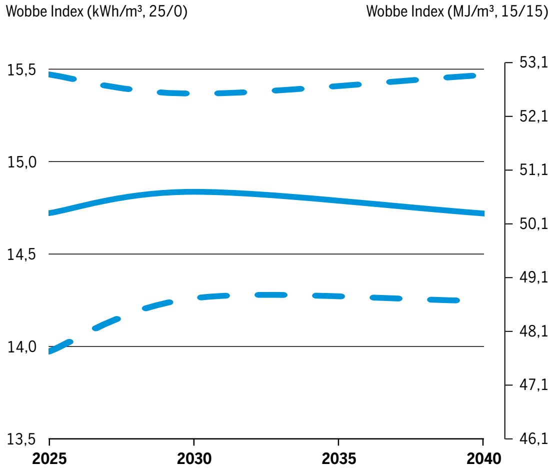


BEMIP WI

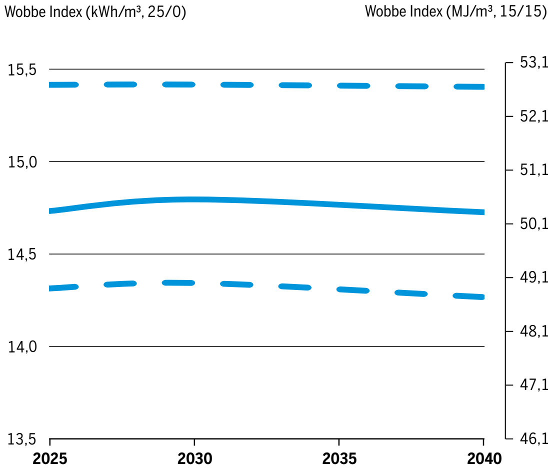


6 The TYNDP 2022 System Assessment report is available here

NORTH-SOUTH CEE WI



SOUTH CORRIDOR WI



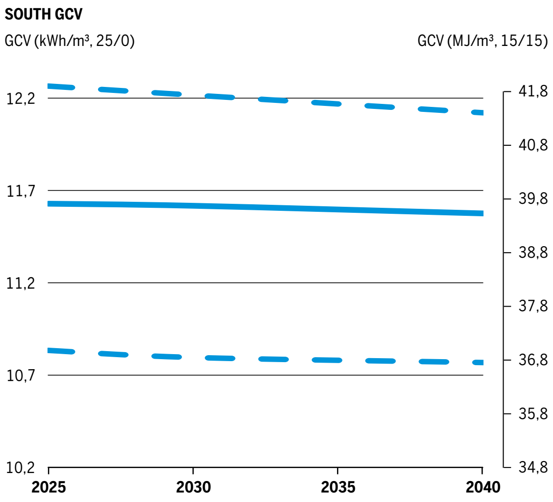
The evolution of median WI appears quite stable throughout the considered time frame, particularly in the North-West and South-North regions.

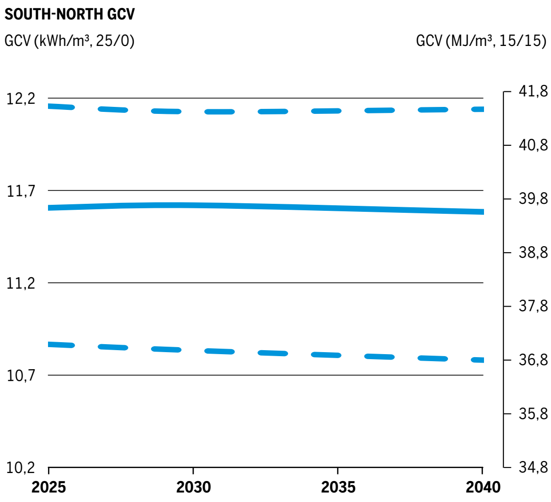
However, other regions like BEMIP and South show a decrease in median values from 2025 to 2040 because of a high share of, respectively, Norwegian gas and biomethane. In South Corridor and North-South, the median values show a slight increase from 2025 to 2030, followed by a decrease in 2040. This fluctuation can be linked to the substantial change in supply sources in 2030 as depicted in the TYNDP 2022 System Assessment Report .

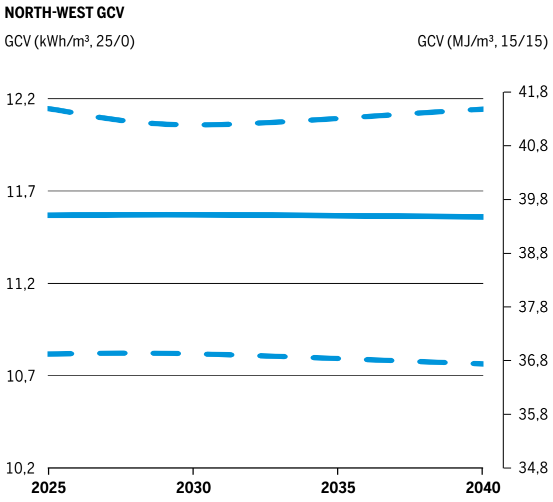
Regarding the extreme values, South-North, BEMIP and South-Corridor exhibit relatively stable trends in contrast to North-South, North-West and South.

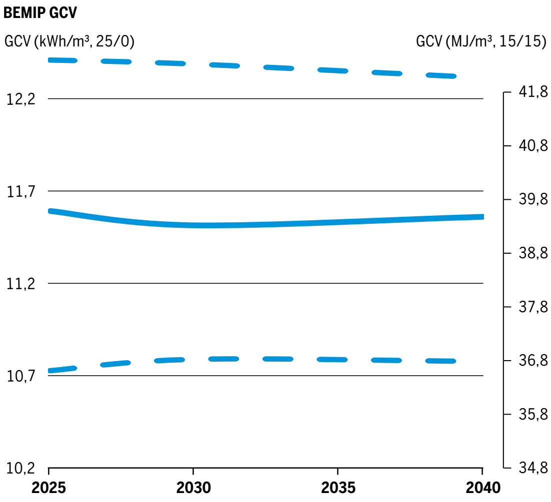
For North-South and North-West regions, the variation in WI range is mainly due to the substantial decline in indigenous production by 2030. While for the South region, the WI range shifts towards lower values in 2040 due to the significant share of biomethane.

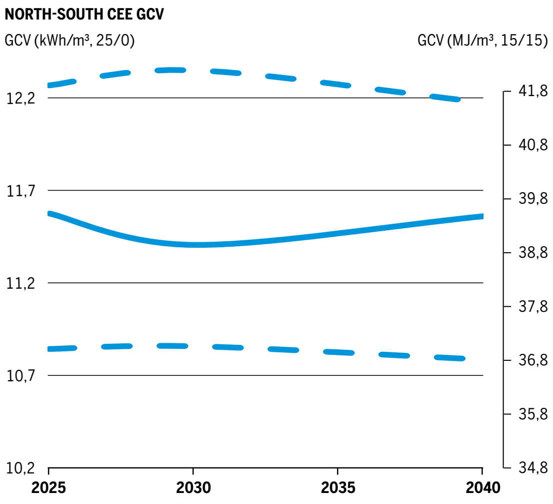
3.2 GCV OVERVIEW

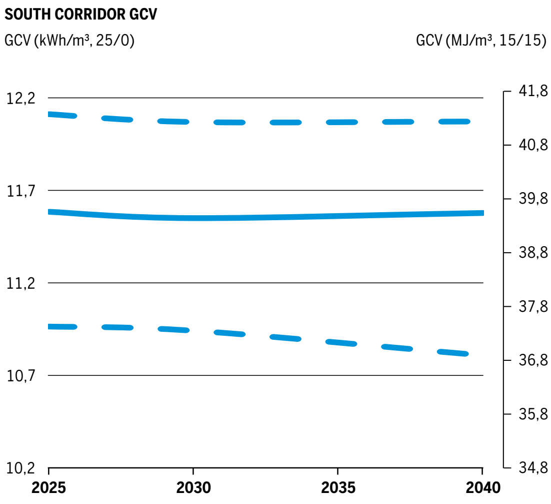












The GCV median values remain relatively stable across all the regions, except for North-South and BEMIP, where a slight decrease is observed in 2030 due to the variation in Russian gas supply during that period. In the case of South and South-North regions, the slight decrease in GCV by 2040 can be attributed to the high share of biomethane.

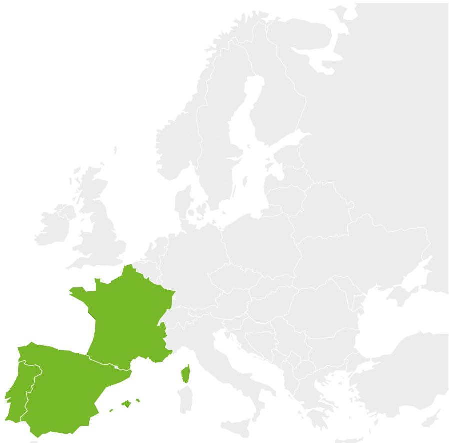
In 2040, all GCV ranges expand due to the co-existence of LNG and Biomethane, except for North-South, BEMIP and South. The reasons vary depending on the specific region. For BEMIP, the tightening of the GCV range is a result of the decrease in indigenous production of gases with both high GCV (DK) and low GCV (PL).

In the North-South zone, the narrowing of the GCV range is primarily due to the decreasing of the high extreme values: lower LNG share in 2040 compared to 2025, along with the cessation of indigenous production of gas with high GCV.

For the South region, the GCV range shifts towards lower values due to the reduction in LNG share in 2040 along with a significant increase in biomethane production.

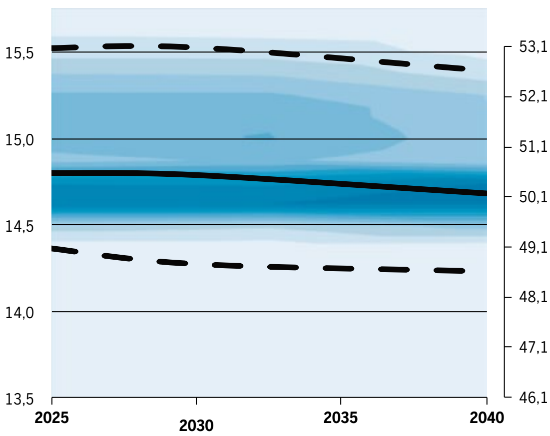
Picture courtesy of Gas Connect Austria

3.3 SOUTH REGION: ES, FR, PT



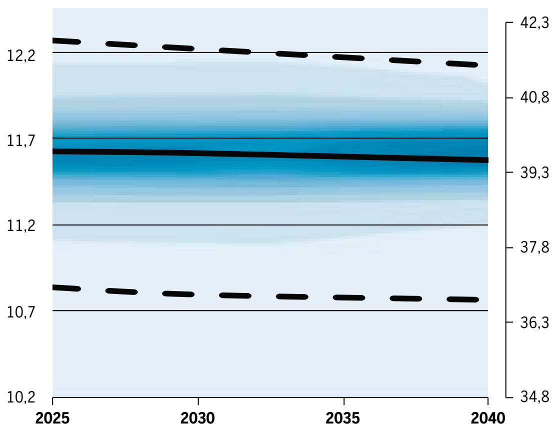
SOUTH WI

Wobbe Index (kWh/m³, 25/0) Wobbe Index (MJ/m³, 15/15)



SOUTH GCV

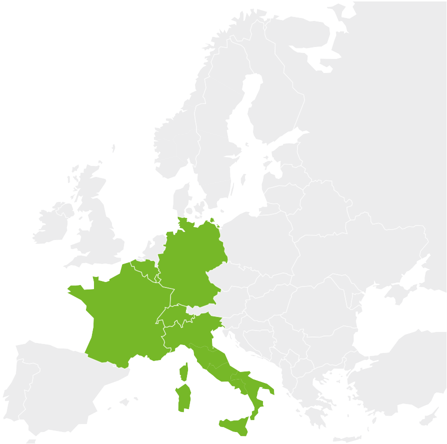
GCV (kWh/m³, 25/0) GCV (MJ/m³, 15/15)

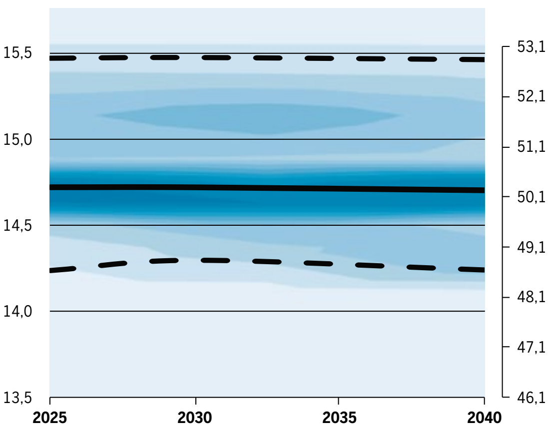


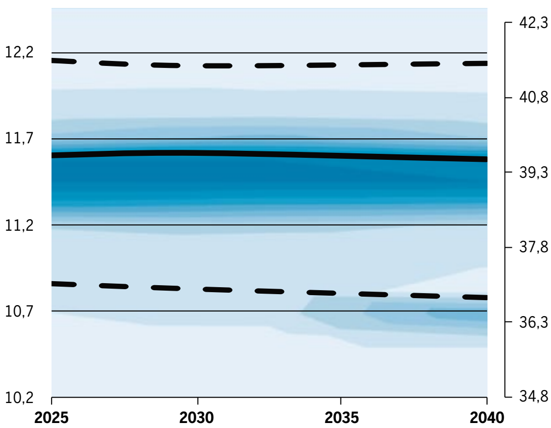
In this region, both WI and GCV ranges exhibit a shift towards lower values from 2025 to 2040. This shift can be attributed to the reduction in LNG share, coupled with a significant increase in biomethane.

Concerning the WI probability distribution, it is possible to highlight a cluster around WI values of 15,1 kWh/m³ in 2025 and 2030, possibly due to the high share of LNG. However, the highest probability density centres around 14,7 kWh/m³, reflecting the consistent share of NO supply from 2025 to 2040. For GCV, the probability distribution is less spread due to the similarity in GCV values of LNG and NO sources.

3.4 SOUTH-NORTH REGION: BE, CH, DE, FR, LU, IT





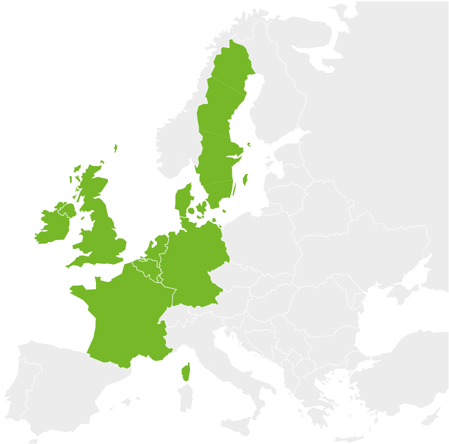


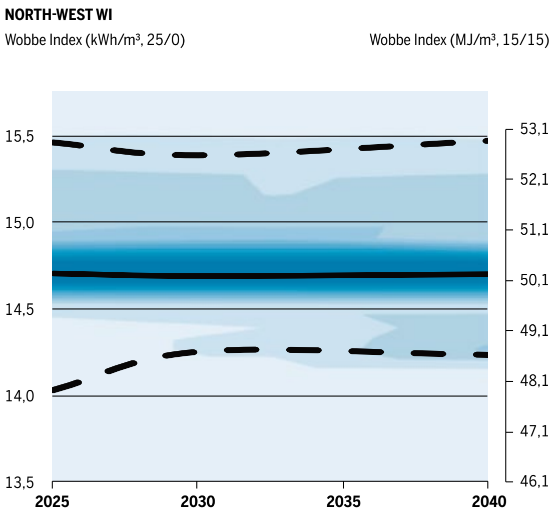
In South-North region, the median values of both WI and GCV show a stable evolution from 2025 to 2040 because of the dominant presence of LNG and NO supply sources. Both WI and GCV ranges narrower from 2025 to 2030. This narrowing can be due to the decline in indigenous production of natural gas in Europe.

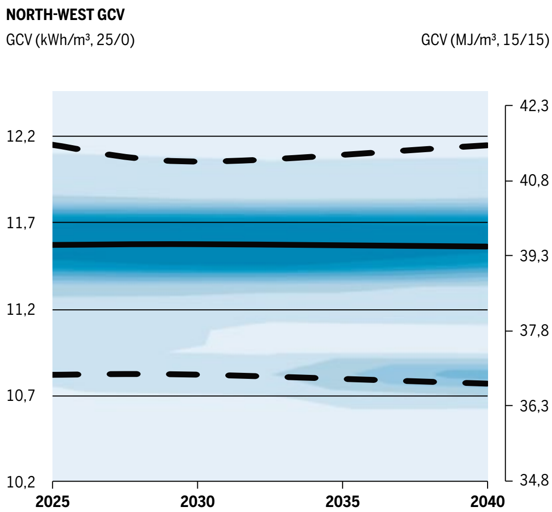
When examining the probability distribution surface plot, a distinct cluster of WI values exceeding 15 kWh/m³ is observable. This phenomenon is attributed to the coexistence of LNG and AZ gas, which contribute to this elevated range of values.

In the context of GCV, the most prominent area of the probability distribution is centred around the median value. This concentration is due to the similar GCV values of LNG and NO. In the probability distribution graphs for both WI and GCV, it is possible to notice the presence of a light blue region around lower values of GCV and WI in 2040. This occurrence can be attributed to the substantial biomethane share in this region.

3.5 NORTH-WEST REGION: SE, DK, DE, NL, BE, LU, FR, UK, IE



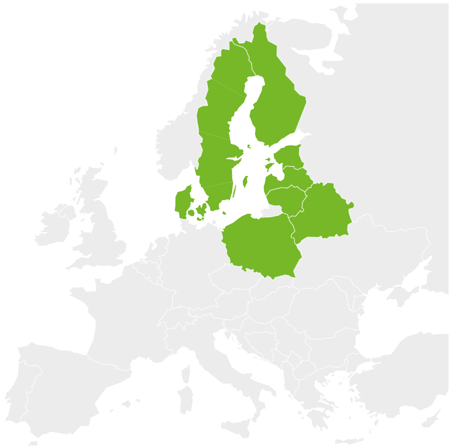




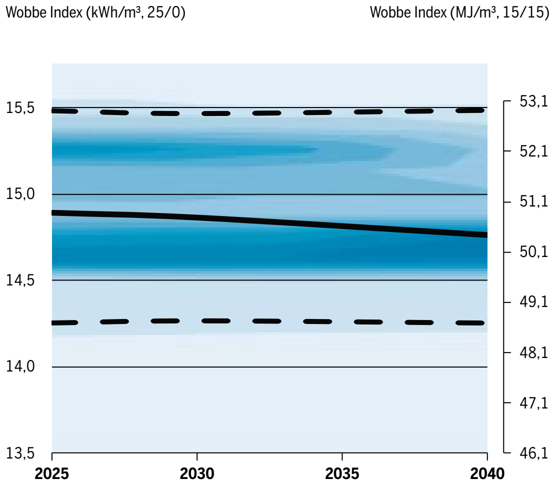
For the North-West region, the median values of WI and GCV remain remarkably stable, largely influenced by the substantial share of NO supply from 2025 to 2040. The tightening of both GCV and WI ranges from 2025 to 2030 can be attributed to the decline in indigenous production and LNG imports. From 2030 to 2040, the range expands due to the simultaneous increase in both LNG and biomethane sources.

The probability distribution is mainly concentrated around the median with a cluster of low values in 2040 due to the increasing share of biomethane.

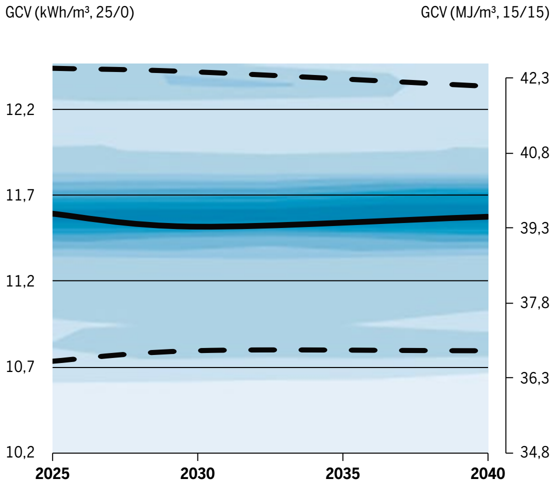
3.6 BEMIP REGION: DK, SE, FI, PL EE, LT, LV



BEMIP WI



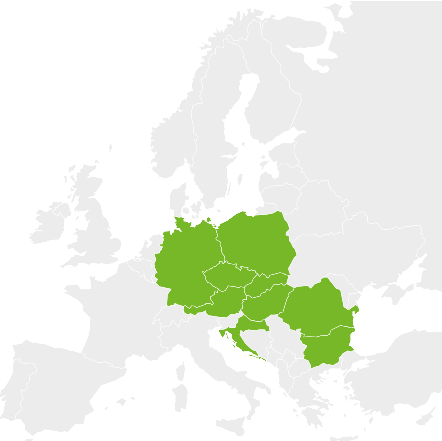
BEMIP GCV



From 2025 to 2030, the WI and GCV median decreases because of the reduction in LNG supply. From 2030 to 2040, the WI median continues to decrease driven by a larger increase in NO compared to LNG. On the other hand, GCV returns to values similar to those of 2025 because of the diminishing share of Russian gas in 2040.

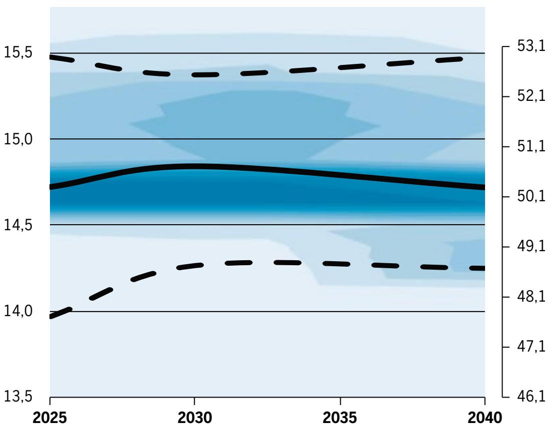
For WI, the presence of a dark blue area around 15,3 kWh/m³ can be due to the relatively high indigenous production of natural gas in DK in 2025 and 2030. This effect is also evident in a corresponding cluster around GCV values of 12.3 kWh/m³. For both GCV and WI, the probability distribution extends up to the 2,5 percentile line. This phenomenon can be explained through the presence of indigenous production from PL between 2025 to 2040.

3.7 CEE: DE, PL, CZ, SK, AT, HU, HR, RO, BG



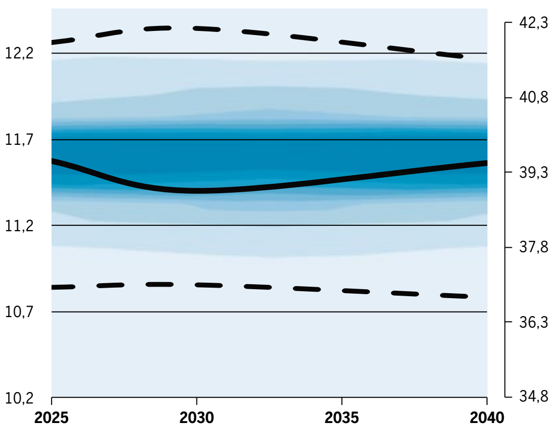
NORTH-SOUTH CEE WI

Wobbe Index (kWh/m³, 25/0) Wobbe Index (MJ/m³, 15/15)



NORTH-SOUTH CEE GCV

GCV (kWh/m³, 25/0) GCV (MJ/m³, 15/15)

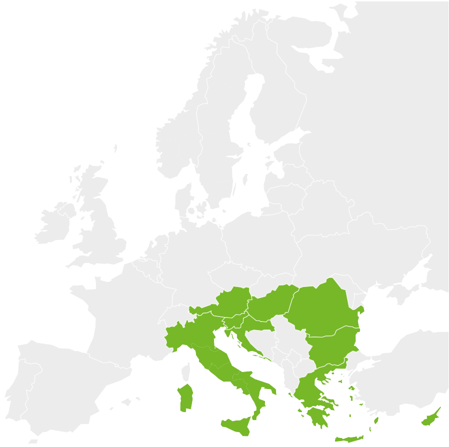


In 2030, the WI median experiences an increase due to a decrease in NO shares. Consequently, the GCV median decreases for the same reason. Moving to 2040, apart from biomethane production, the share mix resembles that of 2025, which explains the decrease in WI and the increase in GCV from 2030 to 2040.

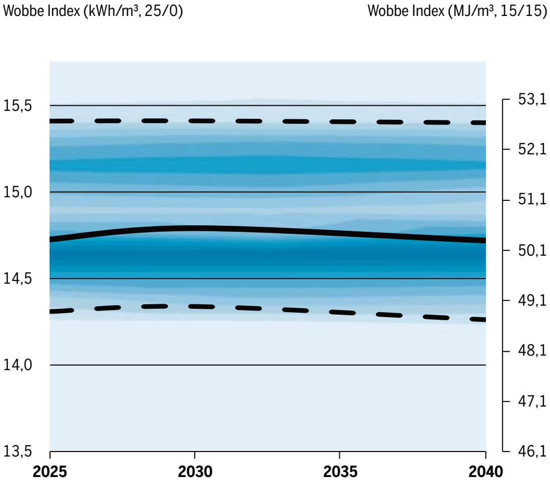
Modelling shows that WI and GCV ranges within the region tend to vary depending on the supply corridor. As a result, probability distributions are projected to vary depending on the correlation of forces between supply corridors.

The WI range tightens from 2025 to 2030 because of a decrease in indigenous production from NL and PL, in addition to declines in NO and LNG. On the contrary, the GCV range widens from 2025 to 2030 because of a slight increase of DK gas share. From 2030 to 2040, the WI range widens because of the increasing shares of biomethane and LNG, while the GCV range shifts towards lower values due to the decrease indigenous production of natural gas and increase in biomethane production.

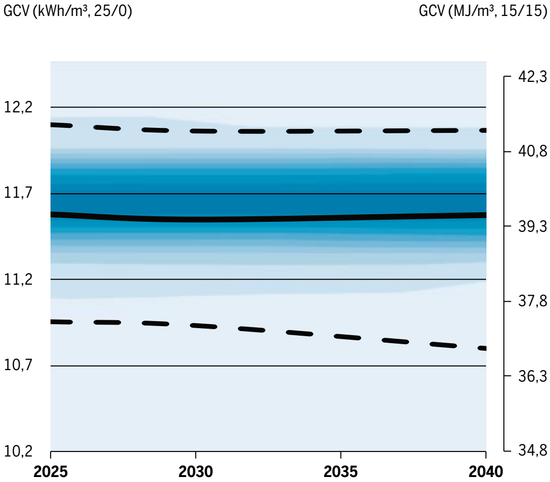
3.8 SOUTHERN CORRIDOR: IT, AT, SI, SK, HU, HR, RO, BG, GR



SOUTHERN CORRIDOR WI



SOUTHERN CORRIDOR GCV



Simulations show that both the WI and GCV ranges exhibit relatively stable patterns from 2025 to 2040, with an expansion observed in 2040 due to the increased biomethane production.

As for the North-South region, in 2030, the Southern Corridor experiences a higher median WI and lower median GCV compared to 2025, in line with the share depicted in the TYNDP 2022 System Assessment report[7].

While the GCV probability distribution appears evenly distributed, the WI surface plot reveals a relatively high probability area around 15.2 kWh/m³. This occurrence can be due to the presence of AZ gas characterizing this region. Additionally, the dark blue region around 14,7 kWh/m³ highlights the substantial share of DZ gas from 2025 to 2040.

The GCV probability distribution tends to centre around 11,7 kWh/m³, representing typical values associated with DZ and LNG.

7 Report available here.

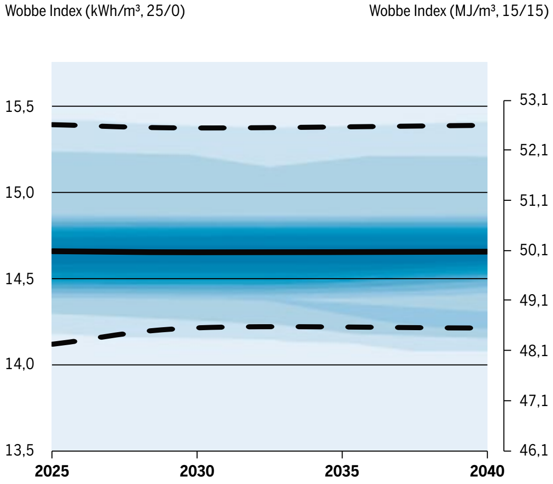
3.9 HYDROGEN SHOWCASE: NORTH-WEST REGION 2040

In this section the influence of two different hydrogen volume fractions, specifically 2 % vol. and 5 % vol., on WI and GCV ranges on the North-West region is presented. The methodology and underlying assumptions are presented in section 2.2. The data used for this analysis is based on TYNDP data which contains ENTSOG's own assumptions and analysis based upon this information. Notably, the hydrogen volumes used for the showcase have been chosen to align with the ongoing discussions on the revision of the of the EU Gas Directive and Regulation.

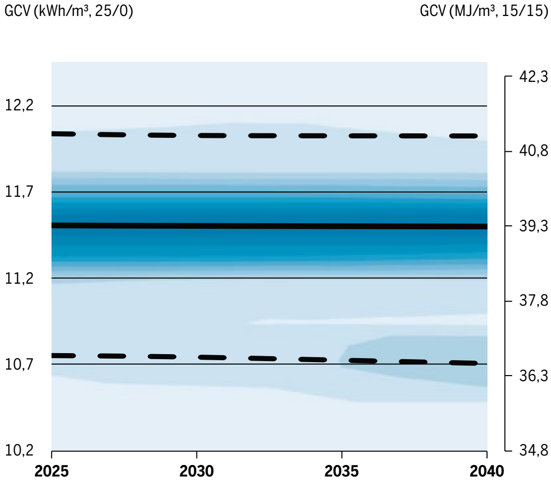
In general terms, both the WI and GCV ranges exhibit trends akin to those observed in the non-blended case. As expected, in case of blends, the median values of both WI and GCV experience a downward shift compared to the non-blended case shown in section 3.5. The influence of H_2 on GCV is notably more pronounced than on WI. In 2040, clusters of lower values of WI and GCV appear due to the high biomethane share in conjunction with H_2 blends. When considering a 5 % H_2 blend, the outlook reveals two distinct clusters of GCV due to the coexistence of both blended and non-blended flows.

3.9.1 INFLUENCE OF 2 % VOL. HYDROGEN ON WI AND GCV

NORTH-WEST WI – 2 % H_2

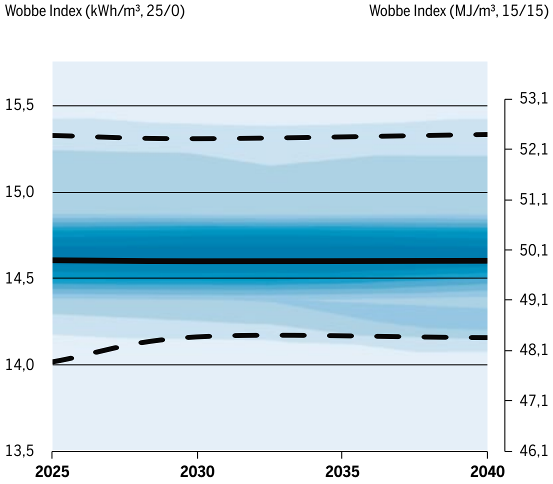


NORTH-WEST GCV – 2 % H_2

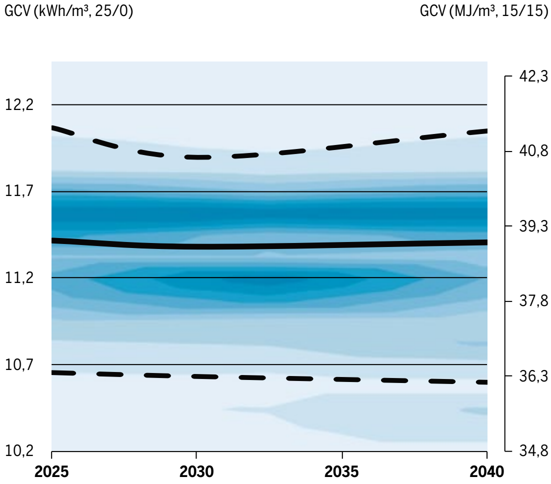


3.9.2 INFLUENCE OF 5 % VOL. HYDROGEN ON WI AND GCV

NORTH-WEST WI – 5 % H_2



NORTH-WEST GCV – 5 % H_2



LIST OF **ABBREVIATIONS**

ENTSOG	European Network of Transmission System Operators for Gas
EU	European Union
GCV	Gross Calorific Value
GRIP	Gas Regional Investment Plan
GQO	Gas Quality Outlook
H_2	Hydrogen
H-gas	High calorific gas
INT NC	Interoperability and Data Exchange Network Code
L-gas	Low calorific gas
LNG	Liquefied Natural Gas
MWh	Megawatt hour
NECP	National Energy and Climate Plan
NeMo	Network Modelling
NP	National Production
PCI	Project of Common Interest
P2G	Power-to-Gas
REG-703	REGULATION (EU) 2015 / 703 of 30 April 2015 establishing a network code on interoperability and data exchange rules
SoS	Security of Supply
SYN MET	Synthetic methane
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
Vol.	Volume
WI	Wobbe Index

COUNTRY CODES (ISO)

AL	Albania
AT	Austria
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BY	Belarus
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
DZ	Algeria
EE	Estonia
ES	Spain
FI	Finland
FR	France
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
LY	Libya
MA	Morocco
ME	Montenegro
MK	Macedonia
MT	Malta
NL	Netherlands, the
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
RU	Russia
SE	Sweden
SI	Slovenia
SK	Slovakia
TM	Turkmenistan
TN	Tunisia
TR	Turkey
UA	Ukraine
UK	United Kingdom

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Publisher ENTSOG AISBL
Avenue de Cortenbergh 100
1000 Brussels, Belgium

Design DreiDreizehn GmbH, Berlin | www.313.de

ENTSOG AISBL
Avenue de Cortenbergh 100 | 1000 Brussels, Belgium
Tel. +32 2 894 51 00

info@entsog.eu | www.entsog.eu